a well of a conductivity type opposite to the conductivity type of said semiconductor substrate that is formed in said semiconductor substrate;

a charge transfer region of a conductivity type opposite to the conductivity type of said well that is formed in said well and joined to said well to form a diode, said diode having an impurity distribution which is uniform along a direction of signal charge transfer;

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a signal charge input portion adapted to input a signal charge to the charge transfer region;

a signal charge output portion adapted to accumulate the signal charge transferred from the charge transfer region; and

a plurality of independent potential supply portions adapted to supply a potential gradient to said well, said plurality of independent potential supply portions supplying said semiconductor region with respectively different potentials,

wherein the signal charge in the charge transfer region is transferred by the potential gradient formed by said plurality of potential supply portions, and

wherein the signal charge in said charge transfer region is transferred by drift over all of said charge transfer region.

REMARKS

Claims 1-6 remain in this application. Non-elected Claims 7-17 have been canceled without prejudice or disclaimer of subject matter. Claims 1 and 4, the independent claims, have been amended to define still more clearly what Applicant regards as his invention. Favorable reconsideration is requested.

In the Office Action dated July 17, 2002, Claims 1-6 were rejected under 35 U.S.C. § 103(a) as being obvious from U.S. Patent 4,912,560 (Osawa) in view of U.S. Patent 5,502,318 (Hynecek).

As is explained in much greater detail in the present application, the present invention is concerned with solving a problem encountered in two-dimensional arrays of image sensing elements. Such elements are conventionally either charge-coupled devices (CCDs") or charge-sweep devices ("CSDs"). CCDs have the drawback that high sensitivity and wide dynamic range are fundamentally incompatible aims, and one much be sacrificed to obtain an improvement in the other. With CSDs, on the other hand, although both of these desiderata can both be obtained, the price is that the nature of the CSD requires line-sequential driving to read out the image that has been picked up. Various efforts to avoid this drawback of the CSD are described in the specification, but additional improvement in techniques that permit one to avoid these problems would be desirable. Such improvement is provided by the present invention.

Independent Claim 1 is directed to a charge transfer apparatus that comprises a semiconductor region of one conductivity type, and a charge transfer region of a conductivity type of the opposite type, joined to the semiconductor region to form a diode. According to Claim 1, the diode has an impurity distribution which is uniform along a direction of signal charge transfer. Also provided in the apparatus are a signal charge input portion adapted to input a signal charge to the charge transfer region, and a signal charge output portion adapted to accumulate the signal charge transferred from the charge transfer region. A plurality of independent potential supply portions are adapted to

supply a potential gradient to the semiconductor region, by supplying the latter region with respectively different potentials. Claim 1 recites also that the signal charge in the charge transfer region is transferred by the potential gradient formed by the plurality of potential supply portions, and that the signal charge in the charge transfer region is transferred by drift over all of that region.

One advantage of an apparatus constructed according to Claim 1, is that high-speed drift transfer of the charge is achieved. As shown in Fig. 2A, the charge transfer region 5 in the semiconductor substrate 1 forms a diode structure having an impurity distribution which is uniform in the signal charge transfer direction, and the plurality of independent potential supply portions 12, 13 and 14, 15 supply the semiconductor region 1 with respectively different potentials, so that a potential gradient is formed over all of the charge transfer region 5. This provides the desired high-speed drift transfer of the charge, along the potential gradient.

Osawa relates to a solid-state image sensor in which vertical and horizontal registers are provided . A charge injection system is used to provide base charge for the light-receiving/storage elements. This charge is discharged to the substrate through the vertical registers by setting gates to low level.

From the Office Action, it appears to Applicant that the Examiner may have assumed that region 113 in Fig. 9 of *Osawa* corresponds to the recited "charge transfer region" of Claim 1. Even if *Osawa* is deemed to teach that regions 113 and 112 constitute a diode structure in which an impurity distribution is made uniform along a direction of transferring charge, however, nothing has been found in that patent that would teach or suggest any means for forming a *potential* gradient in region 113 like the "plurality of

independent potential supplying portions", which as recited in Claim 1 independently supply respectively different potentials. As a result, in region 113, charge is apparently transferred only by diffusion. Thus, the transfer speed would presumably be very slow, unlike what is achieved using the structure of Claim 1. Applicant also notes Fig. 10 of *Osawa*, which shows that region 113 is used in the transfer of a signal charge of one pixel, and thus can be used only for a transfer over a short distance.

The Office Action then cites *Hynecek* as teaching, in Fig. 1, a plurality of independent potential supply portions (Φ_1, Φ_2, and Φ_3). However, Φ_1, Φ_2, and Φ_3 are closed clocked voltage, and do not, in Applicant's view, teach or suggest independent potential supply portions, such as are recited in Claim1. Applicant believes that the Examiner may have misapprehended the following point, which Applicant believes to be of some importance. Regions 50, 52 and 54 are locally doped with an impurity, in higher concentration along the charge transfer direction, and so the surface potentials of the semiconductor region are changed locally in stepped configuration successively as time elapses, thereby moving the charge in bucket-brigade fashion. Such charge transfer system provides an advantage in that plural charge signals can be transferred successively in time series, but also suffers from the problem that, since the signal charge transfer is achieved by changing the potential successively in step configuration, when charge quantity of the signal to be transferred is large and exceeds the size of the step, the charge would overflow, and thus complete signal charge transfer can not be achieved. For example, when signal charge exceeds steps 74 and 82 in Fig. 2, the signal charge overflows and leaks into an area 82.

According to the apparatus recited in Claim 1, in contrast, over a distance much longer that in *Osawa*, drift transfer is used to transfer the signal charge with a higher

speed. And, without limitation of transfer signal charge quantity like that in *Hynecek*, a large quantity of signal charge can be transferred. Thus, even if Φ_1, Φ_2, and Φ_3 are deemed to be independent potential supply portions supplying respectively different potentials, nothing in *Hycenek* would teach or suggest independent potential supply portions meeting the recitations of Claim 1. Accordingly, the proposed combination of that patent with *Osawa* (even assuming for argument's sake that such combination would be permissible) could not meet the terms of Claim 1. That is, even if the proposed combination is made, the result would at the most have potential sources like those of *Hycenek*, but as explained above, that would not meet the terms of Claim 1. Accordingly, that claim is believed to be clearly allowable over those two patents, taken separately or in combination.

Independent Claim 4 recites features similar to those discussed above with respect to Claim 1, and therefore is also believed to be patentable over those references, for the reasons discussed above.

A review of the other art of record has failed to reveal anything which, in Applicant's opinion, would remedy the deficiencies of the art discussed above, as references against the independent claims herein. Those claims are therefore believed patentable over the art of record.

The other claims in this application are each dependent from one or the other of the independent claims discussed above and are therefore believed patentable for the same reasons. Since each dependent claim is also deemed to define an additional aspect of the invention, however, the individual reconsideration of the patentability of each on its own merits is respectfully requested.

REQUEST FOR PERSONAL INTERVIEW

While Applicant's attorney will contact the Examiner by telephone shortly to arrange a personal interview, if the Examiner takes this case up for action before such interview has been scheduled, it is respectfully requested that the Examiner contact Applicant's attorney to schedule such interview.

CONCLUSION

In view of the foregoing amendments and remarks, Applicant respectfully requests favorable reconsideration and early passage to issue of the present application.

Applicant's undersigned attorney may be reached in our New York office by telephone at (212) 218-2100. All correspondence should continue to be directed to our below listed address.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE TO CLAIMS

1. (Twice Amended) A charge transfer apparatus comprising:

a semiconductor region of one conductivity type;

a charge transfer region of a conductivity type opposite to the conductivity type of said semiconductor region that is formed in said semiconductor region and joined to said semiconductor region to form a diode, said diode having an impurity distribution which is uniform along a direction of signal charge transfer;

a signal charge input portion adapted to input a signal charge to the charge transfer region;

a signal charge output portion adapted to accumulate the signal charge transferred from the charge transfer region; and

a plurality of independent potential supply portions adapted to supply a potential gradient to said semiconductor region, said plurality of independent potential supply portions supplying said semiconductor region with respectively different potentials,

wherein the signal charge in the charge transfer region is transferred by the potential gradient formed by said plurality of potential supply portions, and

wherein the signal charge in said charge transfer region is transferred by drift over all of said charge transfer region.

4. (Amended) A charge transfer apparatus comprising:

a semiconductor substrate of one conductivity type;

a well of a conductivity type opposite to the conductivity type of said semiconductor substrate that is formed in said semiconductor substrate;

a charge transfer region of a conductivity type opposite to the conductivity type of said well that is formed in said well and joined to said well to form a diode, said diode having an impurity distribution which is uniform along a direction of signal charge transfer;

a signal charge input portion adapted to input a signal charge to the charge transfer region;

a signal charge output portion adapted to accumulate the signal charge transferred from the charge transfer region; and

a plurality of independent potential supply portions adapted to supply a potential gradient to said well, said plurality of independent potential supply portions supplying said semiconductor region with respectively different potentials,

wherein the signal charge in the charge transfer region is transferred by the potential gradient formed by said plurality of potential supply portions, and

wherein the signal charge in said charge transfer region is transferred by drift over all of said charge transfer region.